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THE INFLUENCE OF INFRASOUND ON TASK PERFORMANCE.

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Summary.

16 subjects were exposed to infrasound and traffic noise while task performance measurements were carried out. Infrasound above the hearing threshold level (120 dB) seems to affect human task performance. An addition duty was carried out 7% slower, and the reaction time in a complex reaction time test was increased 6%. In a cue utilization test there were 80% more errors. Traffic noise at L_{eq} = 71 dB(A) showed no effects.

Introduction.

It has often been claimed that infrasound could influence human performance. Most observations of this kind are from human everyday environment, where both the exposure and the observation of the performance are uncertain. Therefore laboratory experiments are needed where the exposure is well known (infrasound without vibrations, audio frequency sound etc.), and where a number of well defined performance parameters are recorded. Experiments like these have been carried out [1-10] but the results are not very concordant, and further investigation is needed.

This investigation deals with both physiological parameters, task performance and subjective annoyance impressions, but only the task performance recordings have been analysed until now, and they will thus be the only subject of this paper.

Exposure.

The experiments were carried out in an infrasound test chamber built at Aalborg University Centre [11,12]. The chamber is rather large, 16 m^3, in order to avoid psychological reactions from the subjects. The infrasound is generated by 16 large electrodynamic loudspeakers. To allow experiments of long duration the test chamber is equipped with a ventilating system.

Four different exposures were used. In addition to two infrasound signals, a "quiet" exposure was used, and for comparative reasons, an audio frequency noise.

- A - quiet.
- B - traffic noise. This was a recording from a main road in Aalborg. The playback level was L_{eq} = 71 dB(A).
- C - low level infrasound, see figure 1. Total SPL=100 dB.
- D - high level infrasound, see figure 1. Total SPL=120 dB.

C and D were broadband infrasound signals, frequency shaped along the treshold curve 5-25 Hz, which makes the "low" and "high" frequencies equally audible. The total spectrum C is hardly audible, while D is subjectively loud.

Recordings of task performance.

9 different task performance measurements were used. The tests consisted of duties presented either on a small film viewer or on a CRT-display terminal. The duties were answer-

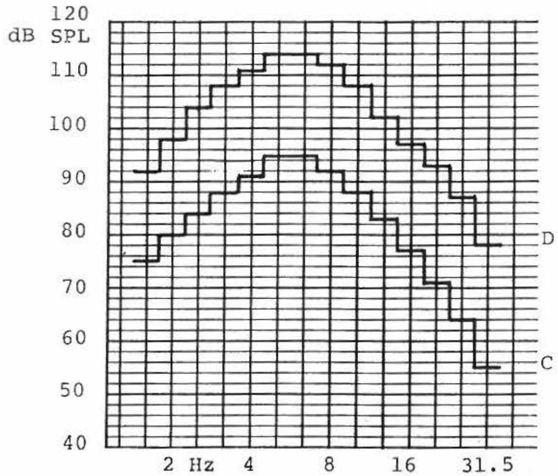

Figure 1.
1/3 octave analysis of the stimuli C and D.
Total SPL:
C: 100 dB
D: 120 dB

ed by pressing pushbuttons. Some of the tests were developed at The Laboratory of Heating and Air Conditioning at The Technical University of Denmark, where the purpose was measurement of task performance during exposure to different conditions of temperature, humidity of air and the like [13]. In the tests the answering of one duty was immediately followed by presentation of the next one.

Test 1 consisted of addition duties. 5 three-digit numbers should be added. Three suggestions of the sum were presented and the subject should choose between these or indicate, that none of them were correct. The four answers were equally probable.

In test 2 nine two-digit figures were presented and the subject should indicate whether they were all different. In 34% of the presentations two or more figures were identical.

In test 3 logical statements of a certain construction were presented. The subject should indicate whether the statement was right or wrong.

Exemples: A precedes B: AB (right)
After A is C: CA (wrong)
C does not follow B: CB (right)
A is not before B: AB (wrong)

Test 4 was a cue utilization test; a modified version of the Tsai-Partington test [14]. The order 1-A-2-B-3-C-4-D etc. should be followed, and the subject was to indicate whether the next sign could be found, see figure 2.

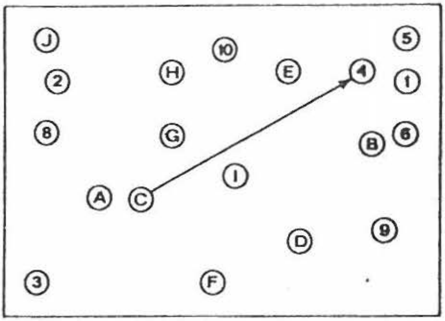

Figure 2.
Example of test 4.

Test 5 was a short time memory test. A list of words was presented, one word at a time. Each word might occur more than once and the person should indicate whether he had seen it before.

Test 6 was a simple reaction time test. When a letter appeared in the centre of the CRT display a pustbutton should be pressed. The time from answering to presentation of the next stimulation was random but uniformly distributed in the range 2-6 seconds.

In test 7 the display was divided into five parts and the letter E appeared in one of them every 2 seconds. The subject should react only on appearance in the centre.

In test 8 the display was divided into two parts by a vertical line. The letters E and F could appear one at a time at either the left or the right side. The subject should only react on an F to the left or an E to the right.

Test 9 was simular to test 2, but carried out with other equipment.

Experimental design.

15 young students and one person of 43 years were used as subjects, half of each sex. During two months they all participated in the experiment four days, each day for 4 hours. In a 4-hour setting 3 hours were used for exposure to one of the four conditions given above. The subjects participated two at a time and they were all exposed to all four conditions, although not in the same order. A latin square design was used in order to balance out learning effects, see table I.

	person number:			
	1-4	5-8	9-12	13-16
1. exposure:	A	B	C	D
2. exposure:	B	C	D	A
3. exposure:	C	D	A	B
4. exposure:	D	A	B	C

Table I. Latin square design of the experiments.

For each setting a strict time table was used, see figure 3.

Results.

From the tests were recorded mean response time and percents of errors (except test 6, where only the response time was recorded).

It is not surprising that the quantities differ strongly from person to person. Therefore all values are normalized, which means that they are divided by the total mean for the person in that particular test. For each sound stimulus mean values and standard deviations of the normalized variables are calculated. For the response times results are shown in figure 4.

Time:	Activities for the first person:	Activities for the second person:	
	audiometrical measurement	fixing electrodes etc. for physiological measurements	
	fixing electrodes etc. for physiological measurements.	audiometrical measurement	
0h 00m	test 6, 7, 8, 9	test 1	sound stimulation
	test 4		
0h 30m	test 2		
	measurement of blood pressure		
1h 00m	test 3	test 6, 7, 8, 9	
	test 5	test 4	
1h 30m	test 6, 7, 8, 9	test 2	
	measurement of blood pressure		
2h 00m	test 1	test 3	
		test 5	
2h 30m		test 6, 7, 8, 9	
	measurement of blood pressure questionnaire for subjective impressions		
3h 00m	audiometrical measurement	taking off electrodes	
	taking off electrodes	audiometrical measurement	

Figure 3.

Time table for each 4-hour experiment.

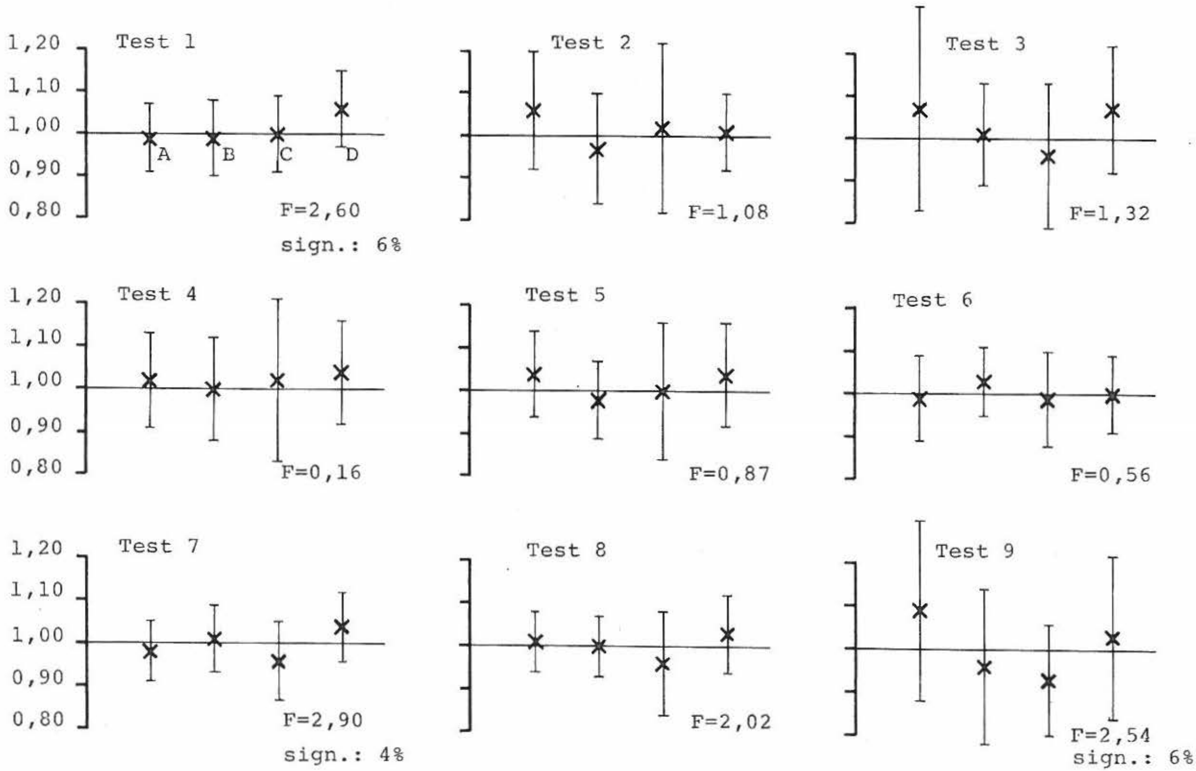

Figure 4. Mean values (x) and standard deviation (vertical bars indicate $\pm$ 1 s.d.) of the normalized response times. F values and significance levels: see text.

It is quite obvious that no general deterioration in the performance caused by the sound stimuli in B, C and D can be seen from the figure. According to the mean values, the subjects worked faster in some tests and slower in others, when exposed to noise.

Before making any conclusions about the influence of the noise on performance it is important to clarify whether the observed differences are so large that they cannot be explained as random. For this purpose a one way analysis of variance has been carried out. In this analysis the H_o hypothesis is: the mean values are all equal. The significance level indicates the probability of obtaining the observed results or values that differ even more if H_o were true. F values and significance levels from the tests are indicated in figure 4. In test 1, 7 and 9 H_o is rejected at 6%, 4% and 6% level, respectively. Only results from these tests are further analysed.

In simple t-tests the values from B, C and D are compared to values in A. The following is observed: Test 1: the response time is longer in D (significant at 2% level). Test 7: the response time is longer in D (3% level). Test 9: the response time is shorter in C (2% level).

The values of the error percents were analysed in a similar way. The analysis of variance only showed significant differences in test 4, and here there were 80% more errors in D than in A (significant at 1% level in a t-test).

Discussion.

In test 9 an improvement was shown when the subjects were exposed to noise C. However, this seems very unlikely, and as test 9 is similar to test 2 where no significant changes were seen, the significance was probably random.

Except for the above mentioned, all alterations in performance appeared as deteriorations when the subjects were exposed to noise D. This seems to indicate that infrasound above the threshold value is able to affect task performance in a negative way.

It is remarkable that no significant changes were seen when the subjects were exposed to traffic noise (B). This indicates that the recorded parameters are not very susceptible to noise. Traffic noise at L_{eq} = 71 dB is subjectively rather disturbing, and the results seem to show that the human being - at least for a few hours - is able to compensate for this, so tasks are carried out without deterioration. Thus task performance measurement may be a poor tool in noise assessment.

With this in mind, the significant deteriorations in performance caused by audible infrasound may be regarded as being more serious than their magnitude immediately seems to indicate.

In the present design of the experiment (latin square) the learning effect is balanced out, but it still contributes to the standard deviation. A further study of this effect might lead to a compensation giving smaller standard deviations and thus more significant changes in performance.

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